Influence of Aging and Surface Contact on the Composition of Cigarette Sidestream Smoke. Models for Environmental Tobacco Smoke

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Introduction

Environmental tobacco smoke (ETS) is a complex mixture derived from sidestream smoke of burning cigarettes and mainstream smoke exhaled by smokers. Its composition is highly variable in indoor environments as it undergoes chemical/physical changes due to dilution and aging influenced by contact with materials. Due to the discussed health impact of ETS on nonsmokers, numerous studies have been performed (Eatough et al. 1990, Guerin et al. 1992), for example, to chemically characterize ETS or to determine its irritative potential. Since it is practically impossible to reproducibly generate "real" ETS, only models of ETS can be used for analytical and biological testing. However, a major problem in developing ETS models is the lack of generally accepted standards for reproducible generation. To obtain information about the influence of aging and surface contact on the composition of cigarette sidestream smoke, fresh sidestream smoke (FSS) was room-aged under various conditions, because FSS is not considered to be an adequate model for ETS.

Method

Smoke Generation

Diluted FSS, age approximately 1 second, was continuously generated via a 30-port automatic smoking machine using 2R1 University of Kentucky standard reference cigarettes. Room-aged sidestream smoke (RASS) was generated by continuously passing diluted FSS at a rate of 20 m^3/hour through a 30-m^3 empty experimental room (epoxy-coated walls and ceiling, PVC floor, door, window pane, fluorescent lights, heat exchangers, ceiling fan). The mean age of RASS was 1.5 hours.

Experiments

In a series of 1-day experiments, the influence on smoke composition of aging alone (empty room) and aging in combination with materials found in rooms was investigated. The following materials were used individually or altogether: wool curtain (22 m^2), wool carpet (11 m^2), wooden book shelf, painted wallpaper (31 m^2). To check the long-term stability of the smoke composition, FSS and RASS (all materials present in the room) were generated over 90 days, 7 days/week, 6 hours/day followed by air-flushing for 18 hours.

Smoke Analyses

Total particulate matter (TPM) was determined gravimetrically using glass fiber filters. Carbon monoxide was monitored continuously by nondispersive infrared photometry of the gas phase. Nicotine was determined by gas chromatography, and aldehydes and ammonia were determined by high-performance liquid chromatography after derivatization. Hydrogen cyanide was determined by headspace gas chromatography. For each 1-day experiment, these parameters were determined at least three times consecutively. During the 90-day experiment the parameters were determined at regular intervals.

Results

One-Day Experiments

Table 1 gives the analytical data for FSS and RASS generated to an equal CO concentration of approximately 30 ppm. In Figure 1, the changes in composition of RASS relative to FSS are shown for those components affected by aging and materials.

Aging alone reduced nicotine and TPM to approximately 30% and 70% of their respective FSS concentrations, whereas other components were not affected or were only slightly affected. The individual material together with aging resulting in the most pronounced overall reductions was a wool curtain, with the final smoke component concentrations ranging between 10% and 60% of those seen for FSS. Aging with all materials resulted in the strongest reductions, with the final smoke component concentrations ranging between 5% and 45% of those seen for FSS. Of all components, nicotine decreased most strongly due to aging alone and ammonia most strongly by aging together with materials.

90-Day Stability

Over a period of 90 days, FSS and RASS (all materials present in the room)

Table 1. Concentration of smoke components in FSS and RASS.

Parameter	FSS	RASS					
		Empty room/ aging	Wool curtain	Wool carpet	Wooden book shelf	Painted wallpaper	All materials together
TPM (µg/L)	10.8	7.1	4.1	6.0	6.4	6.7	3.9
Nicotine (µg/L)	2.49	0.77	0.39	0.81	0.61	0.39	0.23
Ammonia (µg/L)	3.95	3.73	0.46	2.07	1.32	1.49	0.24
Hydrogen cyanide (µg/L)	0.18	0.15	0.11	0.09	0.12	0.10	0.08
Formaldehyde (ppm)	0.51	0.49	0.21	0.25	0.35	0.23	0.11
Acetaldehyde (ppm)	0.75	0.70	0.68	0.71	0.68	0.72	0.68
Acrolein (ppm)	0.11	0.08	0.09	0.08	0.09	0.10	0.09

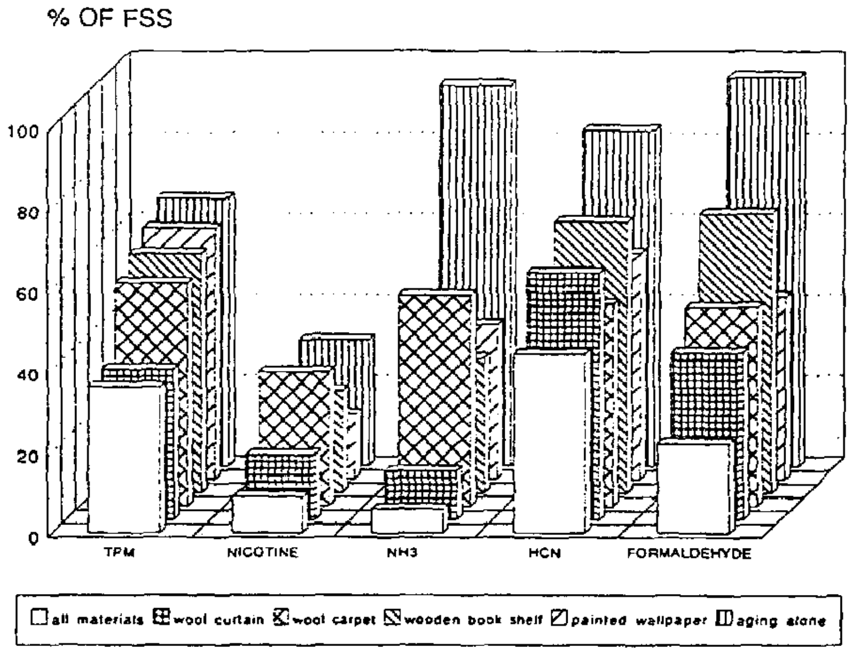

Figure 1. Influence of aging and materials on FSS.

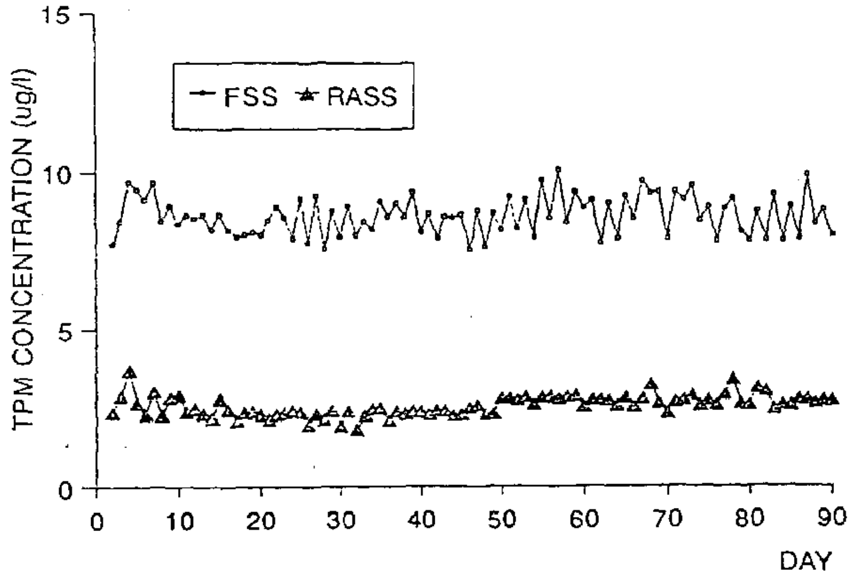

Figure 2. TPM concentration.

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were reproducibly generated. No notable trends for the concentrations of all components determined were observed (see Figure 2 for TPM).

Summary

Large differences in the composition of FSS and RASS were found. The concentrations of RASS components vary considerably depending on the material present. With the setups used, significantly different ETS models were reproducibly generated.

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References

Eatough DJ, Hansen LD, Lewis EA (1990) The chemical characterization of environmental tobacco smoke. Environ Technol 11:1071

Guerin MR, Jenkins RA, Tomkins BA (1992) The chemistry of environmental tobacco smoke: composition and measurement. Lewis Publishers, Inc., Chelsea, MI

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